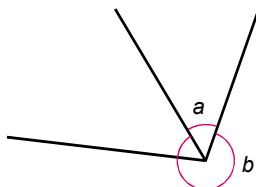
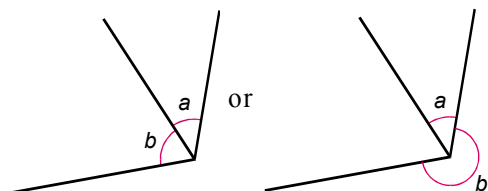


Worksheet 13A (page 13.1)

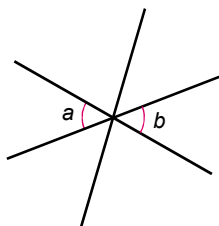
1. (a)



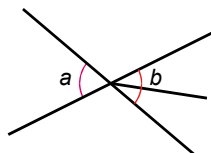
(b)



(c)



(d)



2. (a) $x + 42^\circ = 180^\circ$ (adj. \angle s on st. line)
 $x = 180^\circ - 42^\circ$
 $= \underline{138^\circ}$

(b) $67^\circ + 63^\circ + x = 180^\circ$ (adj. \angle s on st. line)
 $130^\circ + x = 180^\circ$
 $x = 180^\circ - 130^\circ$
 $= \underline{50^\circ}$

3. (a) $x + 75^\circ + 45^\circ = 360^\circ$ (\angle s at a pt.)
 $x + 120^\circ = 360^\circ$
 $x = 360^\circ - 120^\circ$
 $= \underline{240^\circ}$

(b) $60^\circ + x + 32^\circ + 140^\circ + 3x = 360^\circ$ (\angle s at a pt.)
 $4x + 232^\circ = 360^\circ$
 $4x = 128^\circ$
 $x = \underline{32^\circ}$

4. (a) $x + 45^\circ = 180^\circ$ (adj. \angle s on st. line)
 $x = 180^\circ - 45^\circ$
 $= \underline{135^\circ}$

(b) $y + 50^\circ + 45^\circ = 180^\circ$ (adj. \angle s on st. line)
 $y + 95^\circ = 180^\circ$
 $y = 180^\circ - 95^\circ$
 $= \underline{85^\circ}$

(c) $z = \underline{45^\circ}$ (vert. opp. \angle s)

Worksheet 13B (page 13.5)

1. c, r Corresponding angles
 r, a
 r, d Alternate angles
 y, d
 s, c Interior angles on the same side
 d, s

2. (a) $\angle ABG + \angle CBG = 180^\circ$ (adj. \angle s on st. line)
(b) $\angle CBE + \angle BEF = 180^\circ$ (int. \angle s, $AC \parallel DF$)
(c) $\angle GBC = \angle BEF$ (corr. \angle s, $AC \parallel DF$)
(d) $\angle BED = \angle FEH$ (vert. opp. \angle s)
(e) $\angle ABE = \angle BEF$ (alt. \angle s, $AC \parallel DF$)

3. (a) $p + 52^\circ = 180^\circ$ (int. \angle s, $EF \parallel GH$)
 $p = 180^\circ - 52^\circ$
 $= \underline{128^\circ}$
(b) $q = \underline{52^\circ}$ (alt. \angle s, $EF \parallel GH$)

4. $\angle ABC = 49^\circ$ (alt. \angle s, $AB \parallel CD$)
 $\angle ABC + x = 360^\circ$ (\angle s at a pt.)
 $49^\circ + x = 360^\circ$
 $x = 360^\circ - 49^\circ$
 $= \underline{311^\circ}$

$$\begin{aligned}
5. \quad \angle DAB &= x \quad (\text{corr. } \angle \text{s, } AD \parallel BE) \\
\angle FAB &= 65^\circ \quad (\text{corr. } \angle \text{s, } AF \parallel BG) \\
\angle DAB + \angle FAB + 265^\circ &= 360^\circ \quad (\angle \text{s at a pt.}) \\
x + 65^\circ + 265^\circ &= 360^\circ \\
x + 330^\circ &= 360^\circ \\
x &= 360^\circ - 330^\circ \\
&= \underline{\underline{30^\circ}}
\end{aligned}$$

Worksheet 13C (page 13.7)

$$\begin{aligned}
1. \quad x + x + 15^\circ + 55^\circ &= 180^\circ \quad (\angle \text{ sum of } \Delta) \\
2x + 70^\circ &= 180^\circ \\
2x &= 180^\circ - 70^\circ \\
2x &= 110^\circ \\
x &= \underline{\underline{55^\circ}} \\
2. \quad x &= 40^\circ + 44^\circ \quad (\text{ext. } \angle \text{ of } \Delta) \\
&= \underline{\underline{84^\circ}} \\
3. \quad \angle CBD &= x \quad (\text{vert. opp. } \angle \text{s}) \\
\angle BCD &= 38^\circ \quad (\text{base } \angle \text{s, isos. } \Delta) \\
\angle CBD + \angle BCD + \angle BDC &= 180^\circ \quad (\angle \text{ sum of } \Delta) \\
x + 38^\circ + 38^\circ &= 180^\circ \\
x + 76^\circ &= 180^\circ \\
x &= 180^\circ - 76^\circ \\
&= \underline{\underline{104^\circ}} \\
4. \quad (a) \quad \text{In } \triangle BCF, \\
x + x - 20^\circ &= 56^\circ \quad (\text{ext. } \angle \text{ of } \Delta) \\
2x - 20^\circ &= 56^\circ \\
2x &= 76^\circ \\
x &= \underline{\underline{38^\circ}} \\
(b) \quad \text{In } \triangle ABE, \\
y &= x + 30^\circ \quad (\text{ext. } \angle \text{ of } \Delta) \\
&= 38^\circ + 30^\circ \\
&= \underline{\underline{68^\circ}} \\
5. \quad (a) \quad \text{In } \triangle ABE, \\
x &= 65^\circ + 45^\circ \quad (\text{ext. } \angle \text{ of } \Delta) \\
&= \underline{\underline{110^\circ}}
\end{aligned}$$

$$\begin{aligned}
(b) \quad \text{In } \triangle BCD, \\
x + 5y + 30^\circ &= 180^\circ \quad (\angle \text{ sum of } \Delta) \\
110^\circ + 5y + 30^\circ &= 180^\circ \\
5y + 140^\circ &= 180^\circ \\
5y &= 40^\circ \\
y &= \underline{\underline{8^\circ}}
\end{aligned}$$

Worksheet 13D (page 13.11)

$$\begin{aligned}
1. \quad (a) \quad \because \angle GBC &= \angle BEF = 55^\circ \\
&\therefore AC \parallel DF \quad (\text{corr. } \angle \text{s eq.}) \\
(b) \quad \because \angle CBE &= \angle BED = 125^\circ \\
&\therefore AC \parallel DF \quad (\text{alt. } \angle \text{s eq.}) \\
(c) \quad \because \angle CBE + \angle BEF &= 125^\circ + 55^\circ \\
&= 180^\circ \\
&\therefore AC \parallel DF \quad (\text{int. } \angle \text{s supp.}) \\
2. \quad \angle BOA + 90^\circ + 72^\circ &= 180^\circ \quad (\text{adj. } \angle \text{s on st. line}) \\
\angle BOA + 162^\circ &= 180^\circ \\
\angle BOA &= 18^\circ \\
&= \frac{1}{4} \times 72^\circ \\
&= \frac{1}{4} \angle COD \\
3. \quad \because AB &= AC \quad (\text{given}) \\
&\therefore \angle ACB = 70^\circ \quad (\text{base } \angle \text{s, isos. } \Delta) \\
&\because \angle ACB + \angle ACD = 70^\circ + 110^\circ \\
&= 180^\circ \\
&\therefore BCD \text{ is a straight line.} \quad (\text{adj. } \angle \text{s supp.}) \\
4. \quad \angle BCE &= a \quad (\text{alt. } \angle \text{s, } AB \parallel CE) \\
\angle BCE + b &= 180^\circ \quad (\text{adj. } \angle \text{s on st. line}) \\
&\therefore a + b = 180^\circ \\
5. \quad \angle COF &= b \quad (\text{vert. opp. } \angle \text{s}) \\
&\because AB \perp EF \quad (\text{given}) \\
&\therefore \angle FOB = \angle FOA = 90^\circ \\
&\angle BOC + \angle COF = \angle FOA \\
&\therefore a + b = c
\end{aligned}$$

Build-up Exercise 13A (page 13.13)

1. (a) No, a and b are not adjacent angles.

(b) No, a and b are not adjacent angles.

(c) Yes, a and b are adjacent angles.

2. (a) No, x and y are not vertically opposite angles.

(b) Yes, x and y are vertically opposite angles.

(c) No, x and y are not vertically opposite angles.

3. (a) $40^\circ + a = 180^\circ$ (adj. \angle s on st. line)

$$a = \underline{140^\circ}$$

(b) $a + 300^\circ = 360^\circ$ (\angle s at a pt.)

$$a = \underline{60^\circ}$$

(c) $a = \underline{45^\circ}$ (vert. opp. \angle s)

4. (a) $a + 60^\circ = 180^\circ$ (adj. \angle s on st. line)

$$a = \underline{120^\circ}$$

(b) $b + 108^\circ = 180^\circ$ (adj. \angle s on st. line)

$$b = \underline{72^\circ}$$

(c) $30^\circ + c + 48^\circ = 180^\circ$ (adj. \angle s on st. line)

$$c + 78^\circ = 180^\circ$$

$$c = \underline{102^\circ}$$

(d) $40^\circ + 90^\circ + d = 180^\circ$ (adj. \angle s on st. line)

$$d + 130^\circ = 180^\circ$$

$$d = \underline{50^\circ}$$

(e) $90^\circ + e + 30^\circ + 35^\circ = 180^\circ$ (adj. \angle s on st. line)

$$e + 155^\circ = 180^\circ$$

$$e = \underline{25^\circ}$$

(f) $f + 28^\circ + 52^\circ + f = 180^\circ$ (adj. \angle s on st. line)

$$2f + 80^\circ = 180^\circ$$

$$2f = 100^\circ$$

$$f = \underline{50^\circ}$$

5. (a) $a + 240^\circ = 360^\circ$ (\angle s at a pt.)

$$a = \underline{120^\circ}$$

(b) $b + 65^\circ = 360^\circ$ (\angle s at a pt.)

$$b = \underline{295^\circ}$$

(c) $c + 120^\circ + 105^\circ = 360^\circ$ (\angle s at a pt.)

$$c + 225^\circ = 360^\circ$$

$$c = \underline{135^\circ}$$

(d) $d + 90^\circ + 180^\circ = 360^\circ$ (\angle s at a pt.)

$$d + 270^\circ = 360^\circ$$

$$d = \underline{90^\circ}$$

(e) $e + 90^\circ + 45^\circ + 90^\circ = 360^\circ$ (\angle s at a pt.)

$$e + 225^\circ = 360^\circ$$

$$e = \underline{135^\circ}$$

(f) $f + 48^\circ + 102^\circ + 125^\circ = 360^\circ$ (\angle s at a pt.)

$$f + 275^\circ = 360^\circ$$

$$f = \underline{85^\circ}$$

6. (a) $a = \underline{60^\circ}$ (vert. opp. \angle s)

(b) $2b = 52^\circ$ (vert. opp. \angle s)

$$b = \underline{26^\circ}$$

(c) $30^\circ + c = 40^\circ - c$ (vert. opp. \angle s)

$$2c = 10^\circ$$

$$c = \underline{5^\circ}$$

7. (a) $a + 90^\circ + 42^\circ = 180^\circ$ (adj. \angle s on st. line)

$$a + 132^\circ = 180^\circ$$

$$a = \underline{48^\circ}$$

$$b = a \quad (\text{vert. opp. } \angle\text{s})$$

$$= \underline{48^\circ}$$

(b) $m + 90^\circ = 180^\circ$ (adj. \angle s on st. line)

$$m = \underline{90^\circ}$$

$$n = m \quad (\text{vert. opp. } \angle\text{s})$$

$$= \underline{90^\circ}$$

$$\begin{aligned}
 \text{(c)} \quad 2r + r + 72^\circ + r + 2r &= 360^\circ \quad (\angle\text{s at a pt.}) \\
 6r + 72^\circ &= 360^\circ \\
 6r &= 288^\circ \\
 r &= \underline{48^\circ}
 \end{aligned}$$

$$\begin{aligned}
 8. \text{ (a)} \quad 2a + 70^\circ &= 180^\circ \quad (\text{adj. } \angle\text{s on st. line}) \\
 2a &= 110^\circ \\
 a &= \underline{55^\circ}
 \end{aligned}$$

$$\begin{aligned}
 b &= 2a \quad (\text{vert. opp. } \angle\text{s}) \\
 &= 2 \times 55^\circ \\
 &= \underline{110^\circ}
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad a + 38^\circ + 80^\circ &= 180^\circ \quad (\text{adj. } \angle\text{s on st. line}) \\
 a + 118^\circ &= 180^\circ \\
 a &= \underline{62^\circ}
 \end{aligned}$$

$$\begin{aligned}
 b &= a \quad (\text{vert. opp. } \angle\text{s}) \\
 &= \underline{62^\circ}
 \end{aligned}$$

$$\begin{aligned}
 \text{(c)} \quad a &= \underline{35^\circ} \quad (\text{vert. opp. } \angle\text{s}) \\
 b &= \underline{90^\circ} \quad (\text{vert. opp. } \angle\text{s}) \\
 90^\circ + c + 35^\circ &= 180^\circ \quad (\text{adj. } \angle\text{s on st. line}) \\
 c + 125^\circ &= 180^\circ \\
 c &= \underline{55^\circ}
 \end{aligned}$$

$$\begin{aligned}
 9. \text{ (a)} \quad a + 20^\circ + a + 10^\circ + 50^\circ + 5a - 5^\circ &= 180^\circ \\
 &\quad (\text{adj. } \angle\text{s on st. line}) \\
 7a + 75^\circ &= 180^\circ \\
 7a &= 105^\circ \\
 a &= \underline{15^\circ}
 \end{aligned}$$

$$\begin{aligned}
 b &= a + 10^\circ \quad (\text{vert. opp. } \angle\text{s}) \\
 &= 15^\circ + 10^\circ \\
 &= \underline{25^\circ}
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad 3a + 40^\circ + a &= 180^\circ \quad (\text{adj. } \angle\text{s on st. line}) \\
 4a + 40^\circ &= 180^\circ \\
 4a &= 140^\circ \\
 a &= \underline{35^\circ}
 \end{aligned}$$

$$\begin{aligned}
 5b &= a \quad (\text{vert. opp. } \angle\text{s}) \\
 5b &= 35^\circ \\
 b &= \underline{7^\circ}
 \end{aligned}$$

$$\begin{aligned}
 \text{(c)} \quad a + 40^\circ &= 180^\circ \quad (\text{adj. } \angle\text{s on st. line}) \\
 a &= \underline{140^\circ} \\
 a + b &= 160^\circ \quad (\text{vert. opp. } \angle\text{s}) \\
 140^\circ + b &= 160^\circ \\
 b &= \underline{20^\circ}
 \end{aligned}$$

Build-up Exercise 13B (page 13.16)

10. (a) x and y are a pair of corresponding angles.

(b) x and y are a pair of interior angles on the same side.

(c) x and y are a pair of alternate angles.

(d) x and y are a pair of alternate angles.

(e) x and y are a pair of corresponding angles.

(f) x and y are a pair of corresponding angles.

(g) x and y are a pair of corresponding angles.

(h) x and y are a pair of interior angles on the same side.

(i) x and y are a pair of alternate angles.

11. (a) $x = \underline{60^\circ}$ (corr. $\angle\text{s}$, $AB \parallel CD$)

(b) $y = \underline{135^\circ}$ (alt. $\angle\text{s}$, $AB \parallel CD$)

(c) $z + 55^\circ = 180^\circ$ (int. $\angle\text{s}$, $AB \parallel CD$)
 $z = \underline{125^\circ}$

12. (a) $z = \underline{109^\circ}$ (alt. $\angle\text{s}$, $AB \parallel CD$)

(b) $z = \underline{125^\circ}$ (corr. $\angle\text{s}$, $AB \parallel CD$)

(c) $z + 112^\circ = 180^\circ$ (int. $\angle\text{s}$, $AB \parallel CD$)
 $z = \underline{68^\circ}$

13. (a) $x + 115^\circ = 180^\circ$ (adj. $\angle\text{s}$ on st. line)

$$\begin{aligned}
 x &= \underline{65^\circ} \\
 y &= x \quad (\text{corr. } \angle\text{s, } BE \parallel CF) \\
 &= \underline{65^\circ}
 \end{aligned}$$

$$(b) \ x + 310^\circ = 360^\circ \quad (\angle s \text{ at a pt.})$$

$$x = \underline{50^\circ}$$

$$y = x \quad (\text{alt. } \angle s, AB \parallel CD)$$

$$= \underline{50^\circ}$$

$$(c) \ x + 125^\circ = 180^\circ \quad (\text{int. } \angle s, AB \parallel CD)$$

$$x = \underline{55^\circ}$$

$$x + y = 360^\circ \quad (\angle s \text{ at a pt.})$$

$$55^\circ + y = 360^\circ$$

$$y = \underline{305^\circ}$$

$$14. (a) \ \angle BFG = 68^\circ \quad (\text{vert. opp. } \angle s)$$

$$\angle BFG + x = 180^\circ \quad (\text{int. } \angle s, AB \parallel CD)$$

$$68^\circ + x = 180^\circ$$

$$x = \underline{112^\circ}$$

$$(b) \ \angle ABC = y \quad (\text{alt. } \angle s, AB \parallel CD)$$

$$\angle ABC + 284^\circ = 360^\circ \quad (\angle s \text{ at a pt.})$$

$$y + 284^\circ = 360^\circ$$

$$y = \underline{76^\circ}$$

$$(c) \ \angle BCE = 48^\circ \quad (\text{alt. } \angle s, AB \parallel CE)$$

$$\angle BCE + z = 180^\circ \quad (\text{adj. } \angle s \text{ on st. line})$$

$$48^\circ + z = 180^\circ$$

$$z = \underline{132^\circ}$$

$$15. (a) \ 46^\circ + \angle ACD = 180^\circ \quad (\text{int. } \angle s, AB \parallel CD)$$

$$46^\circ + 36^\circ + x = 180^\circ$$

$$82^\circ + x = 180^\circ$$

$$x = \underline{98^\circ}$$

$$(b) \ \angle BAD = 65^\circ \quad (\text{alt. } \angle s, AB \parallel CF)$$

$$y + 48^\circ = 65^\circ$$

$$y = \underline{17^\circ}$$

$$(c) \ \angle DEG = 85^\circ \quad (\text{corr. } \angle s, AB \parallel DE)$$

$$\angle GEF = z \quad (\text{corr. } \angle s, BC \parallel EF)$$

$$\angle DEG + \angle GEF = 120^\circ$$

$$85^\circ + z = 120^\circ$$

$$z = \underline{35^\circ}$$

$$16. (a) \ x = \angle BAD \quad (\text{alt. } \angle s, AB \parallel CE)$$

$$= 46^\circ + 10^\circ$$

$$= \underline{56^\circ}$$

$$y = \underline{46^\circ} \quad (\text{alt. } \angle s, AB \parallel CE)$$

$$(b) \ \angle CDF + 100^\circ = 180^\circ \quad (\text{int. } \angle s, CD \parallel EF)$$

$$\angle CDF = 80^\circ$$

$$\angle ACD = \angle CDF \quad (\text{alt. } \angle s, AC \parallel DF)$$

$$= 80^\circ$$

$$2x + \angle ACD = 180^\circ \quad (\text{int. } \angle s, AB \parallel CD)$$

$$2x + 80^\circ = 180^\circ$$

$$2x = 100^\circ$$

$$x = \underline{50^\circ}$$

$$(c) \ x = \underline{25^\circ} \quad (\text{alt. } \angle s, BC \parallel DE)$$

$$y + \angle ACD = 180^\circ \quad (\text{int. } \angle s, AB \parallel CD)$$

$$y + 75^\circ + x = 180^\circ$$

$$y + 75^\circ + 25^\circ = 180^\circ$$

$$y + 100^\circ = 180^\circ$$

$$y = \underline{80^\circ}$$

$$17. (a) \ 2x = 56^\circ \quad (\text{alt. } \angle s, AB \parallel CF)$$

$$x = \underline{28^\circ}$$

$$\angle BAD + 286^\circ = 360^\circ$$

$$\angle BAD = 74^\circ$$

$$\angle BAD + y = 180^\circ \quad (\text{int. } \angle s, AB \parallel CF)$$

$$74^\circ + y = 180^\circ$$

$$y = \underline{106^\circ}$$

$$(b) \ \angle CBD + 110^\circ = 180^\circ \quad (\text{adj. } \angle s \text{ on st. line})$$

$$\angle CBD = 70^\circ$$

$$\angle BCE = \angle CBD \quad (\text{alt. } \angle s, BD \parallel EC)$$

$$= 70^\circ$$

$$y + \angle BCE + 250^\circ = 360^\circ \quad (\angle s \text{ at a pt.})$$

$$y + 70^\circ + 250^\circ = 360^\circ$$

$$y + 320^\circ = 360^\circ$$

$$y = \underline{40^\circ}$$

$$(c) \ \angle ACG = 40^\circ \quad (\text{corr. } \angle s, BF \parallel CG)$$

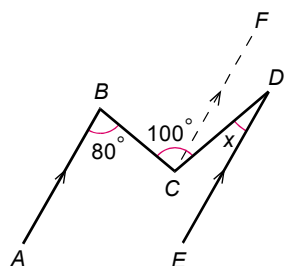
$$\angle ECG = x \quad (\text{corr. } \angle s, DH \parallel CG)$$

$$\angle ACG + \angle ECG = 110^\circ$$

$$40^\circ + x = 110^\circ$$

$$x = \underline{70^\circ}$$

18. (a) Draw a straight line CF which is parallel to AB and ED .



$$\angle BCF = 80^\circ \quad (\text{alt. } \angle \text{s, } AB \parallel CF)$$

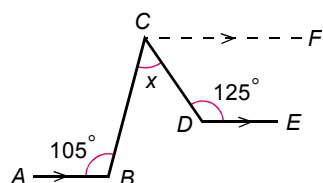
$$\angle DCF = x \quad (\text{alt. } \angle \text{s, } CF \parallel ED)$$

$$\angle BCF + \angle DCF = 100^\circ$$

$$80^\circ + x = 100^\circ$$

$$x = \underline{20^\circ}$$

- (b) Draw a straight line CF which is parallel to AB and DE .



$$\angle DCF + 125^\circ = 180^\circ \quad (\text{int. } \angle \text{s, } CF \parallel DE)$$

$$\angle DCF = 55^\circ$$

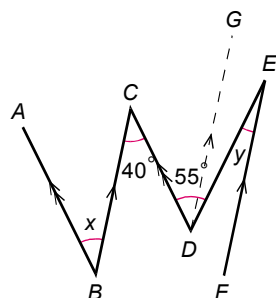
$$\angle BCF = 105^\circ \quad (\text{alt. } \angle \text{s, } AB \parallel CF)$$

$$x + \angle DCF = 105^\circ$$

$$x + 55^\circ = 105^\circ$$

$$x = \underline{50^\circ}$$

- (c) Draw a straight line DG which is parallel to BC and FE .



$$x = \underline{40^\circ} \quad (\text{alt. } \angle \text{s, } AB \parallel CD)$$

$$\angle CDG = 40^\circ \quad (\text{alt. } \angle \text{s, } BC \parallel DG)$$

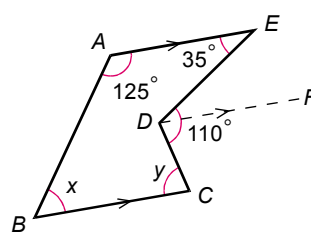
$$\angle EDG = y \quad (\text{alt. } \angle \text{s, } DG \parallel FE)$$

$$\angle CDG + \angle EDG = 55^\circ$$

$$40^\circ + y = 55^\circ$$

$$y = \underline{15^\circ}$$

19. (a) Draw a straight line DF which is parallel to AE and BC .



$$x + 125^\circ = 180^\circ \quad (\text{int. } \angle \text{s, } AE \parallel BC)$$

$$x = \underline{55^\circ}$$

$$\angle CDF = y \quad (\text{alt. } \angle \text{s, } BC \parallel DF)$$

$$\angle EDF = 35^\circ \quad (\text{alt. } \angle \text{s, } AE \parallel DF)$$

$$\angle CDF + \angle EDF = 110^\circ$$

$$y + 35^\circ = 110^\circ$$

$$y = \underline{75^\circ}$$

- (b) $\angle ACD = x$ (alt. \angle s, $AC \parallel DF$)

$$3x + \angle ACD = 180^\circ \quad (\text{int. } \angle \text{s, } AB \parallel CD)$$

$$3x + x = 180^\circ$$

$$4x = 180^\circ$$

$$x = \underline{45^\circ}$$

$$y = x \quad (\text{alt. } \angle \text{s, } CD \parallel EG)$$

$$= \underline{45^\circ}$$

- (c) $\angle BDG = 105^\circ$ (corr. \angle s, $BE \parallel DG$)

$$45^\circ + \angle EDF + 15^\circ = 105^\circ$$

$$\angle EDF + 60^\circ = 105^\circ$$

$$\angle EDF = 45^\circ$$

$$x = \angle EDF \quad (\text{alt. } \angle \text{s, } CE \parallel DF)$$

$$= \underline{45^\circ}$$

Build-up Exercise 13C (page 13.20)

20. (a) $x + 24^\circ + 36^\circ = 180^\circ$ (\angle sum of Δ)

$$x + 60^\circ = 180^\circ$$

$$x = \underline{120^\circ}$$

- (b) $x = 50^\circ$ (base \angle s, isos. Δ)

- (c) $x = 50^\circ + 60^\circ$ (ext. \angle of Δ)

$$= \underline{110^\circ}$$

21. (a) $x + 2x + 30^\circ = 180^\circ$ (\angle sum of Δ)

$$3x + 30^\circ = 180^\circ$$

$$3x = 150^\circ$$

$$x = \underline{50^\circ}$$

(b) $2x = 58^\circ$ (base \angle s, isos. Δ)

$$x = \underline{29^\circ}$$

(c) $x = 22^\circ + 46^\circ$ (ext. \angle of Δ)

$$= \underline{68^\circ}$$

22. (a) $\angle ACB = 65^\circ$ (base \angle s, isos. Δ)

$$a + 65^\circ + \angle ACB = 180^\circ$$
 (\angle sum of Δ)

$$a + 65^\circ + 65^\circ = 180^\circ$$

$$a + 130^\circ = 180^\circ$$

$$a = \underline{50^\circ}$$

(b) $\angle BAC = b$ (base \angle s, isos. Δ)

$$72^\circ + b + \angle BAC = 180^\circ$$
 (\angle sum of Δ)

$$72^\circ + b + b = 180^\circ$$

$$72^\circ + 2b = 180^\circ$$

$$2b = 108^\circ$$

$$b = \underline{54^\circ}$$

(c) $40^\circ + c = 125^\circ$ (ext. \angle of Δ)

$$c = \underline{85^\circ}$$

23. (a) $\angle BDC = 54^\circ$ (base \angle s, isos. Δ)

$$a = \angle BDC + 54^\circ$$
 (ext. \angle of Δ)

$$= 54^\circ + 54^\circ$$

$$= \underline{108^\circ}$$

(b) $\angle ACD = b$ (base \angle s, isos. Δ)

$$\angle ACD + 115^\circ = 180^\circ$$
 (adj. \angle s on st. line)

$$b + 115^\circ = 180^\circ$$

$$b = \underline{65^\circ}$$

(c) $c + 110^\circ = 180^\circ$ (adj. \angle s on st. line)

$$c = \underline{70^\circ}$$

$$\angle BDC = c$$
 (base \angle s, isos. Δ)

$$= 70^\circ$$

$$d + \angle BDC = 180^\circ$$
 (adj. \angle s on st. line)

$$d + 70^\circ = 180^\circ$$

$$d = \underline{110^\circ}$$

24. (a) $\angle CBD = x$ (vert. opp. \angle s)

$$\angle CBD + 30^\circ + 40^\circ = 180^\circ$$
 (\angle sum of Δ)

$$x + 70^\circ = 180^\circ$$

$$x = \underline{110^\circ}$$

(b) $\angle ACB = 37^\circ$ (base \angle s, isos. Δ)

$$\angle BAC + \angle ACB + 37^\circ = 180^\circ$$
 (\angle sum of Δ)

$$\angle BAC + 37^\circ + 37^\circ = 180^\circ$$

$$\angle BAC + 74^\circ = 180^\circ$$

$$\angle BAC = 106^\circ$$

$$x + \angle BAC = 360^\circ$$
 (\angle s at a pt.)

$$x + 106^\circ = 360^\circ$$

$$x = \underline{254^\circ}$$

(c) $\angle ABC + 300^\circ = 360^\circ$ (\angle s at a pt.)

$$\angle ABC = 60^\circ$$

$$x = \angle ABC + 75^\circ$$
 (ext. \angle of Δ)

$$= 60^\circ + 75^\circ$$

$$= \underline{135^\circ}$$

25. (a) $x = 40^\circ$ (vert. opp. \angle s)

$$x + y = 118^\circ$$
 (ext. \angle of Δ)

$$40^\circ + y = 118^\circ$$

$$y = \underline{78^\circ}$$

(b) In ΔADE ,

$$x = 40^\circ + 38^\circ$$
 (ext. \angle of Δ)

$$= \underline{78^\circ}$$

In ΔABE ,

$$x + y = 115^\circ$$
 (ext. \angle of Δ)

$$78^\circ + y = 115^\circ$$

$$y = \underline{37^\circ}$$

(c) In ΔBCE ,

$$x = 25^\circ + 48^\circ$$
 (ext. \angle of Δ)

$$= \underline{73^\circ}$$

In ΔABF ,

$$y = 35^\circ + x$$
 (ext. \angle of Δ)

$$= 35^\circ + 73^\circ$$

$$= \underline{108^\circ}$$

26. (a) In $\triangle BCF$,
 $x = 81^\circ + 40^\circ$ (ext. \angle of Δ)
 $= \underline{121^\circ}$
 $\angle ABE + x = 180^\circ$ (adj. \angle s on st. line)
 $\angle ABE + 121^\circ = 180^\circ$
 $\angle ABE = 59^\circ$

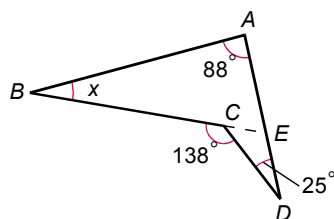
In $\triangle ABE$,
 $y = \angle ABE + 28^\circ$ (ext. \angle of Δ)
 $= 59^\circ + 28^\circ$
 $= \underline{87^\circ}$

(b) In $\triangle ABD$,
 $x = 10^\circ + 15^\circ$ (ext. \angle of Δ)
 $= \underline{25^\circ}$

In $\triangle BDE$,
 $y = x + 55^\circ$ (ext. \angle of Δ)
 $= 25^\circ + 55^\circ$
 $= \underline{80^\circ}$

In $\triangle CDE$,
 $y + z = 100^\circ$ (ext. \angle of Δ)
 $80^\circ + z = 100^\circ$
 $z = \underline{20^\circ}$

(c) Produce BC to meet AD at E .



In $\triangle CDE$,
 $\angle CED + 25^\circ = 138^\circ$ (ext. \angle of Δ)
 $\angle CED = 113^\circ$

In $\triangle ABE$,
 $x + 88^\circ = \angle CED$ (ext. \angle of Δ)
 $x + 88^\circ = 113^\circ$
 $x = \underline{25^\circ}$

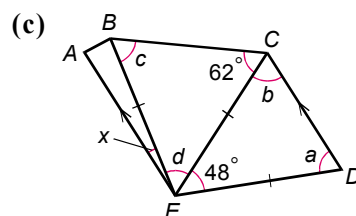
27. (a) $\angle ABD + 125^\circ = 180^\circ$ (int. \angle s, $AC \parallel BD$)
 $\angle ABD = 55^\circ$
 $\angle BDE = \angle ABD$ (alt. \angle s, $AB \parallel CE$)
 $= 55^\circ$

In $\triangle BDE$,
 $\angle BED = \angle BDE$ (base \angle s, isos. Δ)
 $= 55^\circ$
 $x + \angle BDE + \angle BED = 180^\circ$ (\angle sum of Δ)
 $x + 55^\circ + 55^\circ = 180^\circ$
 $x = \underline{70^\circ}$

(b) In $\triangle ABD$,
 $\angle ABD = 35^\circ$ (base \angle s, isos. Δ)
 $x + 55^\circ + 35^\circ + \angle ABD = 180^\circ$ (\angle sum of Δ)
 $x + 55^\circ + 35^\circ + 35^\circ = 180^\circ$
 $x + 125^\circ = 180^\circ$
 $x = \underline{55^\circ}$

In $\triangle ACD$,
 $y + 35^\circ + 55^\circ + 65^\circ = 180^\circ$ (\angle sum of Δ)
 $y + 155^\circ = 180^\circ$
 $y = \underline{25^\circ}$

In $\triangle BCD$,
 $\angle CBD = y$ (base \angle s, isos. Δ)
 $= 25^\circ$
 $z + 65^\circ + y + \angle CBD = 180^\circ$ (\angle sum of Δ)
 $z + 65^\circ + 25^\circ + 25^\circ = 180^\circ$
 $z + 115^\circ = 180^\circ$
 $z = \underline{65^\circ}$



In $\triangle CDE$,
 $b = a$ (base \angle s, isos. Δ)
 $48^\circ + a + b = 180^\circ$ (\angle sum of Δ)
 $48^\circ + a + a = 180^\circ$
 $2a = 132^\circ$
 $a = 66^\circ$

In $\triangle BCE$,
 $c = 62^\circ$ (base \angle s, isos. Δ)
 $c + d + 62^\circ = 180^\circ$ (\angle sum of Δ)
 $62^\circ + d + 62^\circ = 180^\circ$
 $d + 124^\circ = 180^\circ$
 $d = 56^\circ$

$$\begin{aligned}
 \angle AED + a &= 180^\circ \\
 &\quad (\text{int. } \angle \text{s, } AE \parallel CD) \\
 x + d + 48^\circ + a &= 180^\circ \\
 x + 56^\circ + 48^\circ + 66^\circ &= 180^\circ \\
 x + 170^\circ &= 180^\circ \\
 x &= \underline{\underline{10^\circ}}
 \end{aligned}$$

28. (a) In $\triangle ABD$,

$$\begin{aligned}
 \angle ABD &= 28^\circ \quad (\text{base } \angle \text{s, isos. } \triangle) \\
 x &= \angle ABD + 28^\circ \quad (\text{ext. } \angle \text{ of } \triangle) \\
 &= 28^\circ + 28^\circ \\
 &= \underline{\underline{56^\circ}}
 \end{aligned}$$

In $\triangle BDE$,

$$\begin{aligned}
 \angle BED &= x \quad (\text{base } \angle \text{s, isos. } \triangle) \\
 &= 56^\circ
 \end{aligned}$$

In $\triangle ABE$,

$$\begin{aligned}
 y &= \angle BED + 28^\circ \quad (\text{ext. } \angle \text{ of } \triangle) \\
 &= 56^\circ + 28^\circ \\
 &= \underline{\underline{84^\circ}}
 \end{aligned}$$

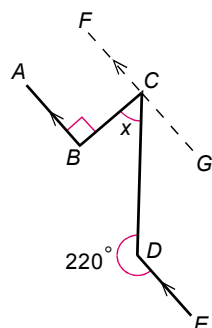
(b) In $\triangle ABE$,

$$\begin{aligned}
 \angle ABE &= 70^\circ \quad (\text{base } \angle \text{s, isos. } \triangle)
 \end{aligned}$$

In $\triangle BCE$,

$$\begin{aligned}
 \angle BCE &= \angle BEC \quad (\text{base } \angle \text{s, isos. } \triangle) \\
 \angle BCE + \angle BEC &= \angle ABE \quad (\text{ext. } \angle \text{ of } \triangle) \\
 2\angle BCE &= 70^\circ \\
 \angle BCE &= 35^\circ \\
 x &= \angle BCE \quad (\text{alt. } \angle \text{s, } AD \parallel EF) \\
 &= \underline{\underline{35^\circ}}
 \end{aligned}$$

(c) Draw a straight line FCG which is parallel to AB and DE .



$$\begin{aligned}
 \angle CDE + 220^\circ &= 360^\circ \quad (\angle \text{s at a pt.}) \\
 \angle CDE &= 140^\circ
 \end{aligned}$$

$$\begin{aligned}
 \angle GCD + \angle CDE &= 180^\circ \quad (\text{int. } \angle \text{s, } FG \parallel DE) \\
 \angle GCD + 140^\circ &= 180^\circ \\
 \angle GCD &= 40^\circ \\
 \angle FCB + 90^\circ &= 180^\circ \quad (\text{int. } \angle \text{s, } FG \parallel AB) \\
 \angle FCB &= 90^\circ \\
 \angle FCB + x + \angle GCD &= 180^\circ \quad (\text{adj. } \angle \text{s on st. line}) \\
 90^\circ + x + 40^\circ &= 180^\circ \\
 x &= \underline{\underline{50^\circ}}
 \end{aligned}$$

Build-up Exercise 13D (page 13.23)

29. $\therefore \angle AOB + \angle BOC = 90^\circ + 90^\circ$
 $= 180^\circ$
 $\therefore AOC$ is a straight line. (adj. \angle s supp.)

30. (a) $\therefore \angle EFB = \angle EGD$
 $\therefore AB \parallel CD$ (corr. \angle s eq.)

(b) $\therefore \angle AFG = \angle DGF$
 $\therefore AB \parallel CD$ (alt. \angle s eq.)

(c) $\therefore \angle BFG + \angle FGD = 135^\circ + 45^\circ$
 $= 180^\circ$
 $\therefore AB \parallel CD$ (int. \angle s supp.)

31. (a) $x + x + y = 360^\circ$ (\angle s at a pt.)
 $2x + y = 360^\circ$
 $y = 360^\circ - 2x$

(b) $\angle BCF = x$ (corr. \angle s, $BE \parallel CF$)
 $\angle BCF + y = 180^\circ$ (adj. \angle s on st. line)
 $x + y = 180^\circ$
 $y = 180^\circ - x$

(c) $\angle CBD = y$ (vert. opp. \angle s)
 In $\triangle BCD$,
 $\angle CBD + x + 50^\circ = 180^\circ$ (\angle sum of \triangle)
 $y + x + 50^\circ = 180^\circ$
 $y = 130^\circ - x$

32. (a) $\therefore COD$ is a straight line. (given)
 $\therefore 2x + 60^\circ = 180^\circ$ (adj. \angle s on st. line)
 $2x = 120^\circ$
 $x = \underline{60^\circ}$

(b) $\therefore \angle AOD + \angle DOB = x + 2x$
 $= 3x$
 $= 3 \times 60^\circ$
 $= 180^\circ$
 $\therefore AOB$ is a straight line. (adj. \angle s supp.)

33. $\therefore a + 90^\circ + a + 90^\circ + a + 90^\circ = 360^\circ$ (\angle s at a pt.)
 $3a + 270^\circ = 360^\circ$
 $3a = 90^\circ$
 $a = 30^\circ$
 $= \frac{1}{3} \times 90^\circ$
 $\therefore a$ is $\frac{1}{3}$ of a right angle.

34. In $\triangle ABC$,
 $\angle ACB = x$ (base \angle s, isos. \triangle)
 $\angle ACB + y = 180^\circ$ (adj. \angle s on st. line)
 $\therefore x + y = 180^\circ$

35. (a) $\therefore \angle ABC = \angle BCD$
 $\therefore AB \parallel CD$ (alt. \angle s eq.)
 (b) $\therefore \angle BCD + \angle CDE = 112^\circ + 68^\circ$
 $= 180^\circ$
 $\therefore CB \parallel DE$ (int. \angle s supp.)

36. $\therefore AEB$ is a straight line. (given)
 $\therefore \angle BEF + 138^\circ = 180^\circ$ (adj. \angle s on st. line)
 $\angle BEF = 42^\circ$
 $\therefore FE \parallel BC$ (given)
 $\therefore \angle CBE = \angle BEF$ (alt. \angle s, $FE \parallel BC$)
 $= 42^\circ$
 $\therefore \angle CBE = \angle BCD$
 $\therefore EB \parallel CD$ (alt. \angle s eq.)

37. (a) $4x + 10^\circ + 6x - 30^\circ + x + 70^\circ + 110^\circ - x = 360^\circ$
 (\angle s at a pt.)
 $10x + 160^\circ = 360^\circ$
 $10x = 200^\circ$
 $x = \underline{20^\circ}$

(b) $\therefore \angle AOD + \angle COD$
 $= 4x + 10^\circ + 110^\circ - x$
 $= 4 \times 20^\circ + 10^\circ + 110^\circ - 20^\circ$
 $= 180^\circ$

$\therefore AOC$ is a straight line. (adj. \angle s supp.)

$\therefore \angle AOB + \angle AOD$
 $= 6x - 30^\circ + 4x + 10^\circ$
 $= 6 \times 20^\circ - 30^\circ + 4 \times 20^\circ + 10^\circ$
 $= 180^\circ$

$\therefore BOD$ is a straight line. (adj. \angle s supp.)

(c) $\angle AOD = 4x + 10^\circ$
 $= 4 \times 20^\circ + 10^\circ$
 $= 90^\circ$
 $\therefore AC \perp BD$


38. $\angle AEF + x = 180^\circ$ (adj. \angle s on st. line)
 $\angle AEF = 180^\circ - x$

In $\triangle AEF$,

$\therefore \angle EAF = \angle AEF$ (base \angle s, isos. \triangle)
 $= 180^\circ - x$
 $= x + y - x$ (given)
 $= y$
 $= \angle AFC$

$\therefore AB \parallel CD$ (alt. \angle s eq.)

39. (a) In $\triangle ABD$,
 $\angle ADE = \angle BAD + \angle ABD$ (ext. \angle of \triangle)
 In $\triangle BCD$,
 $\angle CDE = \angle CBD + \angle BCD$ (ext. \angle of \triangle)
 $= \angle BAD + \angle ABD$ (given)
 $= \angle ADE$
 $\therefore \angle ADE = \angle CDE$


$$\begin{aligned} \text{(b) } \angle ADC &= \angle ADE + \angle CDE \\ &= 2\angle ADE \quad (\text{proved}) \\ &= 2(\angle BAD + \angle ABD) \quad (\text{proved}) \\ &= 2(\angle CBD + \angle ABD) \quad (\text{given}) \\ &= 2\angle ABC \\ \therefore \angle ADC &= 2\angle ABC \end{aligned}$$

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